

- rero [EDS.], Holarctic birds of prey: proceedings of an international conference. World Working Group on Birds of Prey and Owls, Badajoz, Spain.
- HADDANE, B. 1996. The impact of human activities and rehabilitation of raptors: case study, current situation of raptors in Morocco. 2nd International Conference on Raptors 1996, The Raptor Research Foundation and the University of Urbino, Urbino. Italy.
- LAYNA, F.J. 1999. Eurasian Griffons *Gyps fulvus* migrating into Cap Blanc, Mauritania, Western Sahara. *Vulture News* 36:35–36.
- MUNDY, P. 2000. The status of vultures in Africa during the 1990s. Pages 151–164 in R.D. Chancellor and B.-U. Meyburg [EDS.], *Raptors at risk*. World Working Group on Birds of Prey and Owls, Berlin, Germany.
- , D. BUTCHART, J. LEDGER, AND S. PIPER. 1992. *The vultures of Africa*. Academic Press, London, U.K.
- SOCIEDAD ESPAÑOLA DE ORNITOLOGÍA/BIRDLIFE. 1981. Primer censo nacional de buitreras. *Ardeola* 26–27: 165–312.
- . 2001. Seguimiento de la migración en el estrecho, año 2000. Consejería de Medio Ambiente Junta de Andalucía y Sociedad Española de Ornitología, Madrid, Spain.
- SOTO, P. 1986. Le statut du vautour fauve *Gyps fulvus* au maroc. *Birds Prey Bull.* 3:173–181.
- THÉVENOT, M., J.D.R. VERNON, AND P. BERGIER. 2003. *The birds of Morocco*. British Ornithologists' Union, London, U.K.
- VALDÉS, B. 1991. Andalucía and the rif, floristic links and common flora. *Bot. Chron.* 10:117–124.

Received 3 July 2003; accepted 8 December 2004

J. Raptor Res. 39(1):74–79

© 2005 The Raptor Research Foundation, Inc.

ARTIFICIAL NEST STRUCTURE USE AND REPRODUCTIVE SUCCESS OF BARN OWLS IN NORTHEASTERN ARKANSAS¹

PAUL M. RADLEY² AND JAMES C. BEDNARZ

Department of Biological Sciences, P.O. Box 599, Arkansas State University, State University, AR 72467 U.S.A.

KEY WORDS: *Barn Owl*; *Tyto alba pratincola*; *artificial nesting structures*; *breeding chronology*; *reproductive success*; *productivity*; *Arkansas*.

Raptor numbers and productivity in some regions are clearly limited by availability of nest sites (Newton 1979). A shortage of nest sites may hold raptor populations at a breeding density below the level that food would otherwise support (Newton 1979). There are two types of evidence in the literature that support this hypothesis: (1) breeding pairs are scarce in areas where nest sites are absent (but which seem otherwise suitable), and (2) the provision of artificial nest sites is often followed by an increase in breeding density (Newton 1979).

Studies done on Barn Owls (*Tyto alba*) in northern Utah by Marti et al. (1979) supports Newton's (1979) proposal concerning the effect of limited nest sites. Marti et al. (1979) suggested that prior to the appearance of buildings, a breeding population of Barn Owls was virtually nonexistent on his study area due to a paucity of suitable nest sites, but that foraging habitat and prey were

abundant. At this site, Marti et al. (1979) surveyed ca. 50 silos that were used as roosts by Barn Owls, but only one provided a suitable nest site. In 1977, these workers placed nest boxes in 30 silos before the spring nesting period. By the end of 1978, 24 (80%) of the boxes were used by breeding owls (Marti et al. 1979). Similarly, on oil palm (*Elaeis guineensis*) plantations in Malaysia, Duckett (1991) reported that breeding population densities of the Barn Owl (*T. a. javanica*) were limited by available nest sites, despite high densities of several species of rat (*Rattus* spp.; ca. 250–400/ha). Twenty months after Duckett (1991) erected 200 nest boxes in a 1000 ha mature palm plantation (1 box/5 ha), 95% were occupied by nesting Barn Owls. As a result, rat damage to palm trees on the plantation had dropped by 18.1% from the beginning of the study (Duckett 1991). The studies conducted by Marti et al. (1979) and Duckett (1991) support the hypothesis that Barn Owl populations can be limited by the availability of nest sites.

Bloom and Hawks (1983) recorded similar results by testing nest-site limitation in American Kestrels (*Falco sparverius*) in northern California. Of a total of 208 nest boxes examined between 1977–80, 31% were occupied by breeding kestrels (Bloom and Hawks 1983). Bloom and Hawks (1983) suggested that with more strategic

¹ The editorial processing and review of this paper were handled by Clint W. Boal.

² Email address: pratincola@hotmail.com

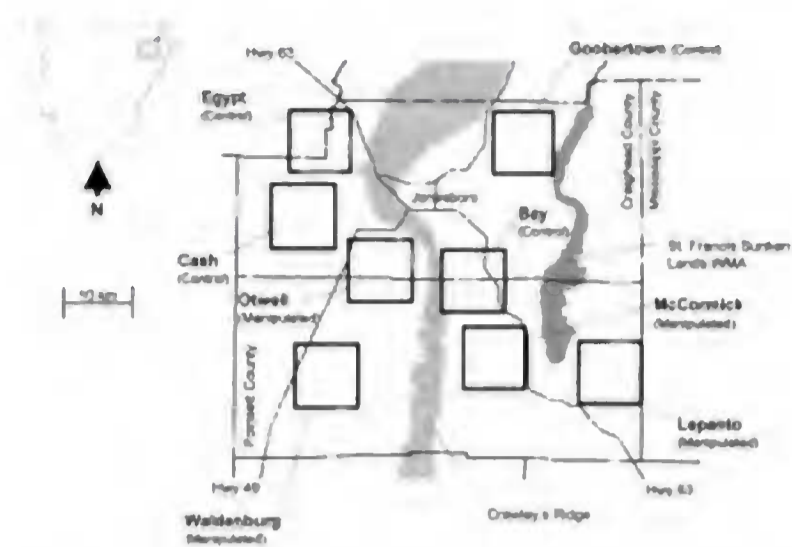


Figure 1. Location of Barn Owl study plots in Craighead and Poinsett counties, northeastern Arkansas, 2000 and 2001.

placement of nest boxes, occupancy could easily have reached 50%. Hamerstrom et al. (1973) reported similar results during a 5-yr study of nest box use by kestrels in Wisconsin.

We tested the hypothesis of nest-site limitation on a population of Barn Owls in northeastern Arkansas by providing artificial nesting structures. To examine the effect that an increase in potential nest sites had upon the local population, we conducted our research on replicate experimental and control plots. Although there is a wealth of data on reproductive success of Barn Owls in other regions (e.g., Marti 1992, Taylor 1994), there are no data for the species in Arkansas. Thus, another objective of this study was to provide data on the reproductive success of Barn Owls in Arkansas and compare these results with data from other areas.

METHODS

Study Area. Our research was primarily conducted in a 1700-km² study area in Craighead and Poinsett counties, northeastern Arkansas (35°30'–36°N, 90°20'–91°W; Fig. 1). These two counties were bisected north to south by a narrow zone of topographic relief known as Crowley's Ridge. To the west of this ridge, the agricultural landscape of both counties was dominated by rice, soybean, and winter wheat. To the east of the ridge, these crops were mixed with cotton.

Within the study area we delineated eight study plots (10 × 10 km) with similar cover types. The proportion of agricultural cover in our study plots varied between 89.6–96.8% (\bar{x} = 93.0%; based on ArcView Geographic Information System [Environmental Systems Research Institute, Inc., Redlands, CA U.S.A.] analysis of USGS digital orthophoto quadrangles [DOQs]). Four of these were east and four were west of Crowley's Ridge (Fig. 1). The plots to the east of the ridge were covered primarily by a relatively even mix of rice and cotton, with some winter wheat and soybean, while the plots to the west of the ridge were dominated by rice with a small contingent of winter wheat and soybean. We designated two plots on either side of the ridge as "manipulated" areas (i.e.,

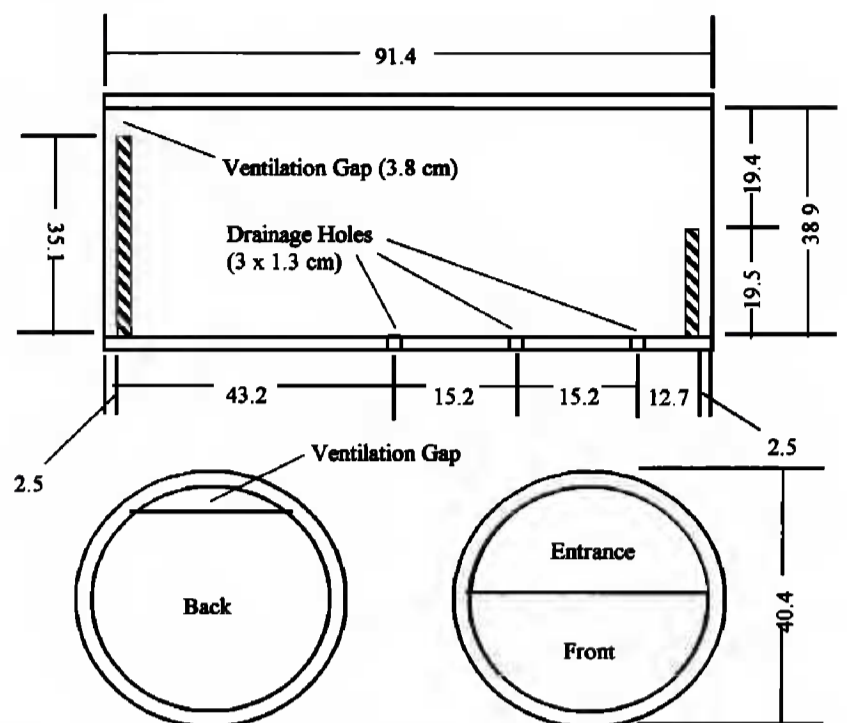


Figure 2. Details and dimensions (cm) of Barn Owl artificial nesting structures placed in manipulated study plots, northeastern Arkansas, 2000.

those in which we placed nest boxes) by the toss of a coin and the remaining served as controls (Fig. 1).

Artificial Nesting Structures. In winter 2000, upon receiving permission from landowners, we erected 12 nesting boxes in each of the four manipulated study plots (Fig. 1). We placed six nest boxes on man-made structures (i.e., grain bins, machine sheds, abandoned cotton gins), where there appeared to be relatively low levels of human activity. We secured the other six structures to isolated trees (i.e., natural structures) standing alone or in small aggregations (Bunn et al. 1982) in or along agricultural fields. All nesting structures were placed between 2.4–6.8 m from the ground (man-made structures: \bar{x} = 4.5 m, range = 2.5–6.8 m; trees: \bar{x} = 4.0 m, range 2.4–6.3 m). We began placing nest boxes on buildings and trees on 27 January 2000 and erected the last one on 7 March 2000. As data on Barn Owl nesting chronology were lacking for Arkansas, we based the timing of our placement of nest boxes on nesting chronology reported from other studies (e.g., Marti 1994). Boxes were placed no closer than 1000 m apart. Duckett (1991) suggested this spacing (>1000 m) to be adequate for nesting Barn Owls in most locations in Malaysia, as this species is generally not territorial over its hunting areas.

Artificial nest structures (design suggested by K. Rowe, Arkansas Game and Fish Commission, pers. comm.) were constructed from 91.4 cm lengths of thick-wall (0.7 cm) polyvinyl-chloride (PVC) pipe, with an inside diameter of 38.9 cm (Fig. 2). At the ends, we secured 1.3 cm thick plywood pieces, coated on both sides with Thompson's Water Seal (Memphis, TN U.S.A.), and inset 2.5 cm from the ends of the pipe. The plywood ends were secured with 3.2 cm length drywall screws (four at each end), and the seam between the plywood ends and PVC pipe was sealed with black silicon caulking. To facilitate drainage, we drilled three 1.3 cm holes in the bottom of the front half of each nest box (Fig. 2).

Barn Owl Surveys. Between 15 March–9 April 2000

and 10–24 April 2001, we searched all manipulated and control plots by day for signs of nesting owls. Likewise, to determine occupancy of artificial nesting structures, we checked all plots in March and June 2000, and again in January, March, June, and September of 2001 (Looman et al. 1996).

With permission from landowners, we visually inspected all farm structures and abandoned cotton gins in all plots for nests. When nests were found, we recorded the location, clutch size, and number of nestlings for each. Nests were monitored periodically until young reached fledging age (ca. 60 d after hatching; Marti 1992; data presented below).

We conducted extensive auditory surveys of all manipulated and control plots between 26 April–4 June 2000, and again between 24 May–13 June 2001. We conducted surveys at night from roads within the study plots. Roads were well distributed, primarily at 1.6 km intervals along section lines throughout all plots. We stopped at all human-developed structures suitable for owl use (barns, cotton gins, etc.) and woodlots with snags, and listened for juvenile food begging calls and adult contact calls for 8–10 min/site. To accomplish this, we used a Seinnheiser microphone mounted on a 46 cm parabolic reflector (Saul Mineroff Electronics, Elmont, NY U.S.A.; Colvin 1984). With this equipment, begging and contact calls could typically be detected from a distance of ca. 0.5 km. All roads in each of the eight study areas were systematically searched. For the reproductive success study, we also monitored nests located off plots. These were either brought to our attention by landowners, or were found when searching appropriate looking sites such as old grain elevators, cotton gins, and wooden barns.

We used the Mayfield Method (1975) to estimate reproductive success. Because of other research objectives, frequency of nest visits were periodic and varied between 2–30 d intervals (typically 10–20 d intervals). For this analysis, we assumed an incubation period of 30.8 d, with 2–3 d between egg-laying (Marti 1992). As we could reasonably estimate a mean brood-rearing period ($\bar{x} = 59.7$; range = 52–67 d) for 10 nests that fledged young in our study area, we used 60 d as the brood-rearing interval for all nests included in the Mayfield analysis. We did not include nests that were found after they failed (e.g., with abandoned eggs) in this analysis.

RESULTS

Nest Boxes. Of the 48 nest boxes erected, four (8.3%) were occupied by owls before the end of the study (a period of ca. 19 mo). All four of these nesting boxes had been erected on man-made structures (i.e., pole or machine sheds). On 23 June 2000, a roosting Barn Owl was flushed from a box placed on a machine shed in the Lepanto study plot (Fig. 1). In January 2001, this same box was found to be occupied by a nesting owl that was incubating eggs and later produced two young. In March 2001, three other nest boxes on the Lepanto study plot were occupied by breeding owls, all of which failed before any young fledged. No nest boxes erected on trees were occupied by Barn Owls during our study.

Nesting. We found a total of 27 nests on and off our

Table 1. Number of Barn Owl nests located in separate study plots (each 100 km²) in northeastern Arkansas in 2000 and 2001.

STUDY PLOT	STATUS ^a	NUMBER OF NESTS	
		IN 2000	IN 2001
Bay	Control	1	2
Cash	Control	0	0
Egypt	Control	0	0
Goobertown	Control	0	0
Lepanto	Manipulated	2	6
McCormick	Manipulated	2	2
Otwell	Manipulated	1	1
Waldenburg	Manipulated	0	0

^a We erected 12 artificial nest structures in each manipulated plot between January and March 2000. No artificial structures were placed in control plots.

study plots (Fig. 1). In 2000, 11 Barn Owl nests were discovered. In the 2001 season, eight of the 2000 nest sites were again in use and eight new nest sites were located. Seventeen of the 27 nests were in four of the eight study plots (Table 1). These nests included four in our nest boxes, nine located by nest searches and checking historical sites, and four in wooden nest boxes erected by landowners prior to our study.

Of the nests found in the four study plots, three were located in control plots ($\bar{x} = 0.75$) and 14 were in manipulated plots ($\bar{x} = 3.5$; Table 1). In 2000, one nest was found in a control plot (Bay) and five were located in three manipulated plots (Lepanto, McCormick, and Otwell). In 2001 we found two nests in the same control plot and nine in the same three manipulated plots (Table 1).

Ten other nests were found off study plots (Fig. 1), four of which were reported to us by landowners (Radley 2002). Two nest sites were located at the Craighead County Fairgrounds in the city of Jonesboro, and the remainder were in agricultural areas adjacent to established plots. Eight of these nests were at sites occupied by nesting owls in both 2000 and 2001; four nests were located in two wooden nest boxes, two nests were in a tree cavity in successive years, and two were found in an old grain elevator located south of the Otwell plot (Fig. 1). Of the last two nests, one was located on a roof truss of an open shed, and one was in the hay loft of a horse barn. No previously unrecorded nests were located in any plot by the auditory surveys.

Breeding Chronology and Reproductive Success. Although Barn Owls may produce more than one brood per year (Lenton 1984, Marti 1994), we detected no second broods during our study. To determine the onset of egg laying, we backdated from the date of fledging for each nest. Based on a total of 13 nests that fledged young

in 2000 and 2001, the mean date of the onset of egg laying for Barn Owls in our study area was 15 February (median = 14 February; range = 9 January–22 March). The earliest date that eggs were actually observed in nests was 8 February and the latest was 5 April. The length of the nesting season (defined here as the period from the onset of first egg laying to fledging of the last young) for the Barn Owl population in our study area averaged 5.8 mo over the 2 study years.

Of the 11 Barn Owl nests found in 2000, six successfully fledged young (55%), two failed, and the fates of three were undetermined. Mean clutch size was 4.5 eggs (range = 3–6, $N = 8$) and mean number of young fledged per successful nest was 3.0 (range = 1–4, $N = 6$). Fledging dates ranged from 6 April–10 July ($\bar{x} = 12$ May, median = 23 May).

In 2001, we found 16 nests, eight of which were at sites that had been used in the previous season. Of the occupied nests, seven fledged young (47%), eight failed, and the fate of one could not be determined. Mean clutch size was 3.1 (range = 1–5, $N = 9$) and mean number of young fledged per successful nest was 2.6 (range = 1–4, $N = 7$). Fledging dates of the eight successful nests ranged from 18 May–5 July ($\bar{x} = 6$ June, median = 11 June). Mean clutch size for the 2 yr was 3.8 ($N = 17$) and mean number of young fledged per successful nest was 2.8 ($N = 13$). Our Mayfield (1975) estimate of Barn Owl nesting success (defined here as the probability of survival of a nest from the start of incubation to the fledging of young) was 0.56 for 23 Barn Owl nests.

DISCUSSION

Artificial Nesting Structures. The lack of use of our nest boxes in 2000 (no nesting, but one owl documented as roosting) was probably because most were not erected until after many breeding Barn Owls had already selected nesting locations. Owls in our study area typically initiated nesting in mid-February. However, most of our nesting structures were not in place until mid to late February. When we initiated this study, there were no data available pertaining to nesting chronology of Barn Owls in Arkansas and we attempted to erect boxes before anticipated nesting in March and April. Because owls started breeding earlier than the original estimated dates for nesting, they may not have had adequate time to find and to habituate to the structures for nesting in 2000.

In 2001, all four nest boxes used by breeding owls were located on man-made structures (i.e., pole or machine sheds) in the Lepanto study plot. Based on casual encounters with owls, this plot appeared to have a high density of Barn Owls (both breeding and nonbreeding individuals) before the nesting structures were erected. However, we had no data pertaining to Barn Owl densities on this plot prior to treatment. The fact that artificial nest structures were exploited in the Lepanto plot, which appeared to have a high number of owls to begin with, suggests that suitable nesting sites in this area may have been limited.

On our study area as a whole, however, relatively few nesting structures were occupied by the time we completed field monitoring in December 2001. Also, no sign of use (e.g., pellets) was observed at any of the other structures. It is possible that the local Barn Owl population was limited by some other environmental factor (e.g., prey availability, juvenile mortality) leading to low occupancy of nest boxes in northeastern Arkansas.

Breeding Chronology and Reproductive Success. The mean date of the onset of egg laying for Barn Owls over a 2-yr period in our study area in northeastern Arkansas was 15 February. In comparison, the mean clutch initiation date for Barn Owls in Utah was 13 March (Marti 1994). The latter estimate was based on a sample of 295 nesting attempts (first brood) over a 16-yr period. Also in Utah, Looman et al. (1996) reported that most owl pairs attempting first clutches (36%) commenced egg laying in the first half of March, while 25% began in late February. Based on a sample of 100 Barn Owl nests in New Jersey, Colvin (1984) gave 14 April as the mean peak of egg laying. The mean length of the nesting season for Barn Owls in our study was 5.8 mo over the 2 study yr. In comparison, Otteni et al. (1972) reported 5.3 mo over a 7-yr period in south Texas, while Looman et al. (1996) gives 6.6 mo as the mean for a 5-yr study in north-central Utah. Barn Owl nesting success in our study (56%) was similar to Barn Owls in the Chesapeake Bay area of Maryland (57%; Reese 1972), but slightly lower than that reported in south Texas (66%; Otteni et al. 1972).

Based on our data, we concluded that Barn Owls in Arkansas produce smaller clutches and fledge fewer young per nesting attempt compared to Barn Owls in most other parts of the world (Table 2). Lower clutch size and reproductive success of owls in Arkansas may be explained, in part, by the well established relationship between latitude and clutch size (Welty and Baptista 1988). However, several investigators (Otteni et al. 1972, Lenton 1984, Wilson et al. 1986) working in areas at considerably lower latitudes reported larger mean clutch sizes than those in our study (Table 2). Likewise, these same investigators reported larger mean clutch sizes than those given by Taylor (1994) in Scotland and Bunn et al. (1982) in England.

There is evidence in the literature that clutch size and fledging success in Barn Owls are related to prey availability and habitat (both of which can vary locally and temporally) as well as other variables associated with latitude. For example, Otteni et al. (1972) reported that the mean clutch size, number of fledglings, and nest success all decreased markedly following a dramatic decline in rodent numbers. Marti and Wagner (1985) found the number of young fledged per pair of Barn Owls in northern Utah varied from 3.6–4.8 until 1982, when it fell to 1.6 following an extremely severe winter that may have reduced local vole populations. In Scotland, Taylor (1994) noted that clutch sizes and fledging success were closely correlated with annual, cyclic variations in vole

Table 2. Mean clutch sizes and number of young fledged for Barn Owl populations in different geographic areas.

GEOGRAPHIC LOCATION	LATITUDE	MEAN CLUTCH SIZE (N)	MEAN NO. OF YOUNG		SOURCE
			FLEDGED PER SUCCESSFUL NEST (N)		
North-central Utah	41°N	7.2 (275)	5.1 (220)		Marti 1994
Peninsular Malaysia	2°55'–1°16'N	6.6 (36)	3.7 (33)		Lenton 1984
Central Mali, Africa	14°15'N	6.1 (140)	3.2 (78)		Wilson et al. 1986
North-central Utah	39°–40°N	5.8 (85)	3.9 (104)		Looman et al. 1996
Chesapeake Bay, Maryland	~38°N	5.5 (74)	3.8 (42)		Reese 1972
South-central Illinois	38°45'N	5.2 (5)	3.8 (5)		Walk et al. 1999
Southwest New Jersey	39°45'N	Not reported	3.8 (125)		Colvin 1984
Southern Texas	28°N	4.9 (91)	Not reported		Otteni et al. 1972
England	~54°N	4.7 (178)	Not reported		Bunn et al. 1982
Scotland	55°–56°N	4.6 (425)	3.1 (490)		Taylor 1994
Northeast Arkansas	35°30'–36°N	3.8 (17)	2.7 (14)		This study
Santa Cruz Island, Galapagos	0°–1°S	3.1 (10)	1.6 (10)		De Groot 1983

(*Microtus* spp.) abundance. Taylor (1994) also found that cover types near the nest site affected clutch size and fledging success. Barn Owl pairs that nested in or near tree plantations produced mean clutch sizes of 5.1 eggs (range = 4.0–6.7), whereas those in low farmland yielded mean clutches of 4.0 eggs (range = 3.0–6.0), but differences between areas were greatest in vole peak years (Taylor 1994). Thus, in Scotland it would appear that cover type affects prey availability, which in turn, influences Barn Owl productivity.

In light of these findings, the poor nest productivity we recorded for Barn Owls in northeastern Arkansas may be due to a relatively low prey base resulting from drought-like conditions that the state had been under for the better part of our study (S. Culp, Craighead County Extension Office, pers. commun.). However, we have no data on local prey availability or abundance for the 2 yr of our study to examine these hypotheses, and recommend that sampling to determine mammal abundance would be important to understand factors that may influence the variation in reproductive success. Also, our study was relatively short term, and it is likely that Barn Owl productivity in northeastern Arkansas may fluctuate over the long term with variations in prey populations. Additional data, collected over more years of study, would be needed to evaluate this possibility. Finally, because most of the nests in our study were in some form of nest box, our data may not be directly comparable to studies involving natural nest locations (i.e., tree cavities).

USO DE ESTRUCTURAS DE NIDIFICACIÓN ARTIFICIALES Y ÉXITO REPRODUCTIVO DE *Tyto alba* EN EL NORESTE DE ARKANSAS

RESUMEN.—Colectamos datos sobre el uso de cavidades de nidificación por parte de *Tyto alba* y sobre su éxito

reproductivo en el noreste de Arkansas durante 2000–01. Se delinearon ocho parcelas de estudio (cada una de 100 km²) que incluían principalmente cultivos de arroz, trigo de invierno, soya y algodón. Aleatoriamente, cuatro de estas parcelas fueron designadas como controles y cuatro como áreas “manipuladas”, en cada una de las cuales se erigieron 12 estructuras de nidificación ($N = 48$ estructuras) entre enero y marzo de 2000. Una de las estructuras fue ocupada como percha dormitorio por un individuo en junio de 2000 y cuatro (8.3%, $N = 48$) fueron ocupadas por individuos nidificantes en marzo de 2001. Encontramos 27 nidos tanto dentro como fuera de las parcelas de estudio, de los cuales 14 estuvieron en las parcelas manipuladas ($\bar{x} = 3.5$ nidos/parcela) y tres en las parcelas control ($\bar{x} = 0.75$ nidos/parcela). De 14 nidos salieron un total de 38 pichones, 10 nidos fracasaron y el destino de tres no fue determinado. La fecha promedio de iniciación de la postura por parte de *T. alba* en nuestra área de estudio fue el 15 de febrero (mediana = 16 de febrero; rango = 28 de diciembre – 25 de marzo), y la duración promedio de la estación de nidificación, desde el comienzo de la postura de huevos hasta el emplumamiento del último pichón, fue de 5.8 meses. El tamaño de nidada promedio fue 3.8 ($N = 17$) y el número promedio de pichones emplumados por nido exitoso fue 2.7 ($N = 14$). La productividad de los nidos de *T. alba* en nuestro estudio fue considerablemente menor que la reportada por otros estudios sobre esta especie realizados alrededor del mundo. El pobre desempeño reproductivo pudo haberse debido a que los tamaños de las poblaciones de presas eran relativamente pequeños debido a las condiciones de sequía sufridas por la región del noreste de Arkansas durante el estudio.

[Traducción del equipo editorial]

ACKNOWLEDGMENTS

Major funding was provided by the Arkansas Game and Fish Commission and was facilitated by Karen Rowe. Additional monetary support was contributed by the Arkansas Audubon Society Trust. The Keeling Co. of Jonesboro, Arkansas, gave a generous reduction on the price of the PVC pipe necessary to build artificial nesting structures. We thank J.D. Wilhide, V. Hoffman, C.J. George, J. Holt, T. Bader, B. Cannon, M. Cannon, D. Ripper, L. Wilf, M. Barnett, C. McCown, K. Levenstein, L. Alterman, and D. Feldman for assistance in the field. Also, we thank all the landowners who gave us permission and access to their lands. We greatly appreciate the contributions of Eric Forsman, who reviewed an earlier draft of this manuscript. Lastly, we would like to thank C. Boal, M. Martell, and two anonymous reviewers for their valuable suggestions and constructive editing of this manuscript.

LITERATURE CITED

- BLOOM, P.H. AND S.J. HAWKS. 1983. Nest box use and reproductive biology of the American Kestrel in Lassen County, California. *Raptor Res.* 17:9–14.
- BUNN, D.S., A.B. WARBURTON, R.D.S. WILSON. 1982. The Barn Owl. Buteo Books, Vermillion, SD U.S.A.
- Colvin, B.A. 1984. Barn Owl foraging behavior and secondary poisoning hazard from rodenticide use on farms. Ph.D. dissertation, Bowling Green State Univ., Bowling Green, OH U.S.A.
- DE GROOT, R.S. 1983. Origin, status and ecology of the owls in Galápagos. *Ardea* 71:167–182.
- DUCKETT, J.E. 1991. Management of the Barn Owl (*Tyto alba javanica*) as a predator of rats in oil palm (*Elaeis guineensis*) plantations in Malaysia. *Birds Prey Bull.* 4: 11–23.
- HAMERSTROM, F., F.N. HAMERSTROM, AND J. HART. 1973. Nest boxes: an effective management tool for kestrels. *J. Wildl. Manag.* 37:400–403.
- LENTON, G.M. 1984. The feeding and breeding ecology of Barn Owls (*Tyto alba*) in peninsular Malaysia. *Ibis* 126:551–575.
- LOOMAN, S.J., D.L. SHIRLEY, AND C.M. WHITE. 1996. Productivity, food habitats, and associated variables of Barn Owls utilizing nest boxes in north central Utah. *Great Basin Nat.* 56:73–84.
- MARTI, C.D. 1992. Barn Owl (*Tyto alba*). In A. Poole, P. Stettenheim, and F. Gill [Eds.], *The birds of North America*, No. 1. Academy of Natural Sciences, Philadelphia, PA and the American Ornithologists' Union, Washington, DC U.S.A.
- . 1994. Barn Owl reproduction: patterns and variation near the limit of the species' distribution. *Condor* 96:468–484.
- AND P.W. WAGNER. 1985. Winter mortality in common Barn Owls and its effect on population density and reproduction. *Condor* 87:111–115.
- , ———, AND K.W. DENNE. 1979. Nest boxes for the management of Barn Owls. *Wildl. Soc. Bull.* 7:145–148.
- MAYFIELD, H.F. 1975. Suggestions for calculating nest success. *Wilson Bull.* 87:456–466.
- NEWTON, I. 1979. Population ecology of raptors. T. & A.D. Poyser, London, U.K.
- OTTENI, L.C., E.G. BOLEN, AND C. COTTAM. 1972. Predator-prey relationships and reproduction of the Barn Owl in southern Texas. *Wilson Bull.* 84:434–448.
- RADLEY, P.M. 2002. Artificial nest structure use, post-fledging habitat use, and dispersal of Barn Owls (*Tyto alba pratincola*) in the Delta region of Arkansas. M.S. thesis, Arkansas State Univ., Jonesboro, AR U.S.A.
- REESE, J.G. 1972. A Chesapeake Barn Owl population. *Auk* 89:106–114.
- TAYLOR, I. 1994. Barn Owls: predator-prey relationships and conservation. Cambridge University Press, Cambridge, U.K.
- WALK, J.W., T.L. ESKER, AND S.A. SIMPSON. 1999. Continuous nesting of Barn Owls in Illinois. *Wilson Bull.* 111. 572–573.
- WELTY, J.C. AND L. BAPTISTA. 1988. *The life of birds*. 4th Ed. Saunders College Publishing, New York, NY U.S.A.
- WILSON, R.T., M.P. WILSON, AND J.W. DURKIN. 1986. Breeding biology of the Barn Owl (*Tyto alba*) in central Mali. *Ibis* 128:81–90.

Received 21 October 2003; accepted 17 November 2004
Associate Editor: Clint Boal